

WE CLAIM:

1. A particle beam processing device being smaller in size and having higher efficiency that causes a chemical reaction on a substrate, comprising:
 - a power supply;
 - a particle generating assembly located in an evacuated vessel and connected to the power supply operating at a first voltage in a range of 110kVolts or less, the particle generating assembly including at least one filament for generating a plurality of particles upon heating;
 - a foil support assembly operating at a second voltage, which is higher than the first voltage, to permit at least a portion of said particles to travel from the first to the second voltage and exit the foil support assembly, the foil support assembly comprising a thin foil made of titanium or alloys thereof having a thickness of 10 micrometers or less; and
 - a processing assembly for receiving said particles exiting the foil support assembly for use to cause said chemical reaction.

2. The particle beam processing device of claim 1, wherein a machine yield (K) of the processing device is determined by Dose representing energy absorbed per unit mass, Speed representing a feeding rate of the processing device, and Current representing a number of electrons extracted from the heated filament, according to:

$$K = \frac{\text{Dose} \cdot \text{Speed}}{\text{Current}}$$

wherein the machine yield (K) is above 30/L where L is the machine width measured in feet, and

whereby: K is machine yield measured in Mrads·feet/min/mAmp,

Dose is energy absorbed per unit mass measured in Mrads,

Speed is feed rate of the substrate measured in feet/min, and

Current is a number of electrons extracted from filament measured in mAmp.

3. The particle beam processing device of claim 1, wherein the evacuated vessel has an operating volume in a range of 0.05-145 ft³.

4. The particle beam processing device of claim 1, wherein the at least one filament is constructed of wire such as tungsten or tungsten alloy and is spaced across a length of the foil support assembly.

5. The particle beam processing device of claim 1, wherein the particle generating assembly further comprises:

a first grid to control a quantity of the plurality of particles being drawn from the at least one filament, the first grid being operated at a third voltage which is higher than the first voltage.

6. The particle beam processing device of claim 5, wherein the particle generating assembly further comprises:

a second grid positioned adjacent the first grid and operating at the first voltage, the second grid acting as a gateway for the particles before accelerating from the first voltage to the second voltage.

7. The particle beam processing device of claim 1, wherein the foil support assembly comprises a plurality of openings to pass the plurality of particles out of the evacuated vessel and into the processing assembly.

8. The particle beam processing device of claim 1, wherein the processing assembly comprises:

a plurality of gas inlets to inject gas to complete the chemical reaction.

9. The particle beam processing device of claim 8, wherein the gas injected into the processing assembly comprises:

gas other than oxygen to displace oxygen existing in the processing assembly.

10. The particle beam processing device of claim 1, further comprising:

a protective lining surrounding at least a portion of the periphery of the particle beam processing device.

11. The particle beam processing device of claim 10, wherein the protective lining is capable of absorbing radiation with residuals less than or equal to 0.1 mrem per hour.

12. A particle beam processing device being smaller in size and having higher efficiency that causes a chemical reaction on a substrate, comprising:

a power supply;

a particle generating assembly located in an evacuated vessel and connected to the power supply operating at a first voltage in a range of 110kVolts or less, the particle generating assembly including at least one filament for generating a plurality of particles upon heating;

a foil support assembly operating at a second voltage, which is higher than the first voltage, to permit at least a portion of said particles to travel from the first to the second voltage and exit the foil support assembly, the foil support assembly comprising a thin foil made of aluminum or alloys thereof having a thickness of 20 micrometers or less; and

a processing assembly for receiving said particles exiting the foil support assembly for use to cause said chemical reaction.

13. The particle beam processing device of claim 12, wherein a machine yield (K) of the processing device is determined by Dose representing energy absorbed per unit mass, Speed representing a feeding rate of the processing device, and Current representing a number of electrons extracted from the heated filament, according to:

$$K = \frac{\text{Dose} \cdot \text{Speed}}{\text{Current}}$$

wherein the machine yield (K) is above 30/L where L is the machine width measured in feet, and

whereby: K is machine yield measured in Mrads·feet/min/mAmp,

Dose is energy absorbed per unit mass measured in Mrads,

Speed is feed rate of the substrate measured in feet/min, and

Current is a number of electrons extracted from filament measured in mAmp.

14. The particle beam processing device of claim 12, wherein the evacuated vessel has an operating volume in a range of 0.05-145 ft³.

15. The particle beam processing device of claim 12, further comprising:
a protective lining surrounding at least a portion of the periphery of the particle beam processing device, the protective lining being capable of absorbing radiation with residuals less than or equal to 0.1 mrem per hour.

16. A method for causing a chemical reaction on a substrate in a particle beam processing device, comprising:

creating a vacuum in a particle generating assembly having at least one filament;

heating the at least one filament to create a plurality of particles;

operating the particle generating assembly at a first voltage having a range of 110kVolts or less;

operating a foil support assembly having a thin foil at a second voltage, which is higher than the first voltage, to cause at least a portion of said particles to travel from the first voltage to the second voltage, and to exit the vacuum in the particle generating assembly, the thin foil being made of titanium or alloys thereof and having a thickness of 10 micrometers or less; and

passing the exiting particles through the thin foil to enter a processing assembly where the substrate is being exposed to the particles.

17. The method of claim 16, wherein a machine yield of the processing device is above $30/L$ wherein L is a width of the processing device measured in feet according to a formula of:

$$K = \frac{\text{Dose} \cdot \text{Speed}}{\text{Current}}$$

whereby: K is machine yield measured in Mrads·feet/min/mAmp,

Dose is energy absorbed per unit mass measured in Mrads,

Speed is feed rate of the substrate measured in feet/min, and

Current is a number of electrons extracted from filament measured in
mAmp.

18. The method of claim 16, wherein the particle generating assembly is contained in a evacuated vessel having an operating volume in a range of 0.05-145 ft³.
19. The method of claim 16, further comprising the step of:
injecting gas other than oxygen into the processing assembly to complete the chemical reaction.
20. The method of claim 16, further comprising the step of:
surrounding at least a portion of a periphery of the particle beam processing device with a protective lining to absorb radiation generated when the plurality of particles decelerate, the protective lining being capable of absorbing radiation with residual less than or equal to 0.1 mrem per hour.

21. A method for causing a chemical reaction on a substrate in a particle beam processing device, comprising:

creating a vacuum in a particle generating assembly having at least one filament;

heating the at least one filament to create a plurality of particles;

operating the particle generating assembly at a first voltage having a range of 110kVolts or less;

operating a foil support assembly having a thin foil at a second voltage, which is higher than the first voltage, to cause at least a portion of said particles to travel from the first voltage to the second voltage, and to exit the vacuum in the particle generating assembly, the thin foil being made of aluminum or alloy thereof and having a thickness of 20 micrometers or less; and

passing the exiting particles through the thin foil to enter a processing assembly where the substrate is being exposed to the particles.

22. The method of claim 21, wherein a machine yield of the processing device is above $30/L$ wherein L is a width of the processing device measured in feet according to a formula of:

$$K = \frac{\text{Dose} \cdot \text{Speed}}{\text{Current}}$$

whereby: K is machine yield measured in Mrads·feet/min/mAmp,

Dose is energy absorbed per unit mass measured in Mrads,

Speed is feed rate of the substrate measured in feet/min, and

Current is a number of electrons extracted from filament measured in
mAmp.

23. The method of claim 21, wherein the particle generating assembly is contained in a evacuated vessel having an operating volume in a range of 0.05-145 ft³.
24. The method of claim 21, further comprising the step of:
injecting gas other than oxygen into the processing assembly to complete the chemical reaction.
25. The method of claim 21, further comprising the step of:
surrounding at least a portion of a periphery of the particle beam processing device with a protective lining to absorb radiation generated when the plurality of particles decelerate, the protective lining being capable of absorbing radiation with residual less than or equal to 0.1 mrem per hour.